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Original Paper

Assessment of silage quality of phytogenic fortified feed samples in mini-silos for ruminants

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This study was conducted to assess the silage quality of *Zingiber officinale* fortified samples in a completely randomized design. The samples consisted of four treatments as samples: Cassava peel (65%) + Moringa leaf (15%) + PKC (20%)+ Ginger (0 g), Cassava peel (65%) + Moringa leaf (15%) + PKC (20%) + ginger (200 g), Cassava peel (65%) + Moringa leaf (15%) + PKC (20%) + ginger (300 g), Cassava peel (65%) + Moringa leaf (15%) + PKC (20%) + ginger (400 g). The physical characteristics; colour, smell, texture, pH, temperature and mould status were observed. All samples retained their original colour, had pleasant alcoholic smell with a firm texture, the pH ranged from 4.2–4.4, temperature range of 25–26 °C with sample D having the highest temperature range of 26 °C while samples A and B had the same temperature of 25.5 °C. The mould status showed absence of mould. The chemical composition revealed that dry matter ranged from 40.86% (sample B) to 54.68% (sample D). Crude protein content ranged from 13.30% to 14.88%, crude fibre content of the samples was significantly (p <0.05) different and it ranged from 14.67% to 22.14%. The mineral concentrations of the samples were higher in *Zingiber officinale* samples except in sample A where potassium was higher (100.40 mg 100 g^{-1}) than in other samples. Volatile fatty acid composition showed that lactic acid (3.24–4.86%) had higher concentration than other acids. It can therefore be concluded that *Zingiber officinale* fortified sample showed better nutritional potential as ruminant feed.

Keywords: volatile fatty acid, silage, *Zingiber officinale*, ruminants

1 Introduction

Ruminant feed comprises forages,agro-industrial by-products and concentrates (Schroeder, 2004). However, the forages are inadequate and of low quality during the dry season. This results in stress, low productivity and even death of the animal causing great economic loss to the farmer (Ibhaze and Fajemisin, 2015), hence the need for consistent availability and supply of feeds is of paramount significance. Silage (a forage, crop residues or agro-industrial by-products preserved by fermentation) (Moran, 2005) production is one of the means to achieving this as it can be fed as basal ration as well as feed supplement especially during the dry season. In a bit to improve intake and digestion and consequent optimum utilization of feed by the animals, researchers adopt various measures such as addition of feed materials high in protein as well as intake enhancers (Phytogenics) of which ginger belongs to this category.

Many active ingredients from plants are regarded as phytogenic feed additives. Phytogenic feed additives are plant-derived products used in animal feeding to improve their performance (Mohammed and Yusuf, 2011). *Zingiber officinale* (ginger) is a perennial plant that may act as a pro-nutrient because of the vast active ingredients it has been reported to contain (Mohammed and Yusuf, 2011). It is a potential functional food/ingredient not only because of being known as good sources of antioxidants but also as a good source of phyto-medicine (Adediran et al., 2014). It is a herbal plant that is nutritionally adequate and locally available in Nigeria that can be harnessed as feed additives (Ademola et al., 2009). Volatile fatty acids (VFA's) such as lactic, acetic, butyric and propionic acids, as well as ammonia and ethanol are by-products of anaerobic fermentation of organic matter and these acids serve as source of energy to ruminants. The amount of the different acids produced has an unswerving effect

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on shelf- life and feeding quality. This study is therefore aimed at evaluating the silage quality made from *Moringa oleifera* leaves, cassava peel and palm kernel cake fortified with ginger.

2 Materials and Methods

2.1 Location of Experiment

The experiment was conducted at the small ruminants unit of the Teaching and Research (T & R) Farm while the laboratory analysis was carried out at the Nutrition Laboratory of Animal Production and Health, Federal University of Technology, Akure. Akure is located on longitude 4.944055 °E and 5.82864 °E, and latitude 7.491780 °N with annual rainfall ranging between 1,300 mm and 1,650 mm average maximum and minimum daily temperature of 38 °C and 27 °C respectively (Daniel, 2015).

2.2 Gross composition (g 100 kg^{-1}) of the experimental diet

Diet A: cassava peel (65 kg) + palm kernel cake (15 kg) + moringa leaves (20 kg) + ginger (0 g).

Diet B: cassava peel (65 kg) + palm kernel cake (15 kg) + moringa leaves (20 kg) + ginger (200 g).

Diet C: cassava peel (65 kg) + palm kernel cake (15 kg) + moringa leaves (20 kg) + ginger (300 g).

Diet D: cassava peel (65 kg) + palm kernel cake (15 kg) + moringa leaves (20 kg) + ginger (400 g).

2.3 Silage production

The cassava peel, palm kernel cake, moringa leaves and ginger were measured as stated in 2.2 and were mixed thoroughly (manually) on a cleaned floor and after mixing, each diet was put into different plastic silos of 4 litres and 120 litres. The materials were properly compressed, covered with nylon and weighted with sand bag to prevent entering of air and then covered with the plastic lids and kept to ferment for 21days.

2.4 Determination of physical characteristics

At 21 days of ensiling, the 4litres silo was used for the analysis. The physical characteristics of the ensiled diets in terms of smell, colour, texture, temperature and pH were determined. The colour was determined using the colour chart, the smell was perceived using the sense organ of smell while the texture was ascertained by taking a hand full of the sample and squeezing it to check for seepage of the juice. The pH value was determined by using a portable pH meter. A 100 gram sample of the silage was thoroughly mixed with 100 ml distilled water (*w*/*v*) and the mixture was allowed to stay for 10 mins, and stirred again. The liquid was poured into a beaker, the pH meter was inserted into the beaker and the value was noted. The temperature was determined by inserting a laboratory thermometer into the silage for 3 mins and the temperature was recorded. The mould status of the silage was determined by visual observation.

2.5 Analytical procedures

The proximate and mineral compositions were determined according to the methods of AOAC (1990) while the fibre fractions were done using the method of Van Soest and Robertson (1985). Metabolizable energy was calculated according to the method of Pauzenga (1985). The preparation of samples for determination of VFAs by gas chromatography method was based on Manni and Caron's procedure (Manni and Caron, 1995).

2.6 Experimental Design and Statistical Analysis

The experimental layout was a completely randomized design. Data obtained were subjected to Analysis of Variance ANOVA using SAS version 9.2 (SAS, 2012) and where significant difference between means exist, Duncan Multiple Test (DMRT) was used using the same statistical package.

3 Results and discussion

3.1 Physical Characteristics of experimental samples

The physical characteristic of ensiled experimental samples is presented in Table 1. The pH of ensiled materials is a measure of its acidity. The pH ranged from 4.2–4.4 indicating that all diets had adequate dry matter which did not restrict fermentation for the production of acids. The values are in tandem with the report of (Bilal, 2009; Nhan et al., 2009) for good silage (3.75–4.70) in the tropics. All samples had pleasant, alcoholic smell suggesting proper fermentation and they all retained their original colour. The samples were firm in texture, which may be due to high fibre content of cassava peel which helped in maintaining a firm structure within the silage. Also this could be attributed to the prior wilting of the materials which reduced the moisture content before ensiling. Temperature ranged from 25 °C to 26 °C with sample D having the highest temperature range of 26 °C while samples A and B had the same temperature of 25.5 °C. Good silage should be in the range of 25 °C to 30 °C as high temperature during ensiling reduces lactic acid concentration, aerobic stability, increase pH, DM losses (Weinberg et al., 2001; Ashbell et al., 2002) and maillard reaction in silage. The absence of mould observed in all the silages suggests that the low pH which indicates adequate concentration of lactic acid created an unfavorable condition for spoilage organisms like clostridia to thrive. Also, the air-tight laboratory silos used in this study would have excluded possible microbial growth and oxidation from air contamination.

3.2 Chemical and Mineral compositions of experimental samples

As shown in Table 2, the dry matter ranged from 40.86% (sample B) to 54.68% (sample D). Although no significant (p >0.05) difference was observed in the crude protein content (13.30–14.88%) but diets containing ginger had higher values which may suggest that ginger could have the ability to release the proteins in feed materials when incorporated with ginger. However, these values are above the critical 8% crude protein requirement by ruminants for optimum microbial activities in the rumen (Norton, 2003). The crude fibre content of the samples which ranged from 14.67–22.14% suggesting that many of the soluble nutrients were not degraded and would be adequate to support rumination. The values were within the requirement of 8–33% crude fibre suggested by Castrillo (2001). Ether extract (EE) values of the diets were moderate as higher values indicates an increase in the energy density of the diets which may allow maximal fat intake but may alter rumen microbial metabolism (Jenkins and McGuire, 2006). Minerals are needed for the maintenance of body fluid and tissues, prevention of decreased appetite, weight loss, secretion of hormones, enzymes and "pica". The mineral composition of ensiled samples is presented in Table 3. Results showed that the mineral concentrations of the samples were higher in *Zingiber officinale* fortified samples except in sample A where potassium was higher (100.40 mg 100 g^{-1}) than in other samples. The mineral concentrations recorded in all the samples indicated that all the samples would be adequate in supplying the mineral requirements of the animals. Potassium requirements for ruminants are within 50–80 mg 100 g^{-1} (NRC, 1984).

3.3 Volatile fatty acids and ammonium concentrations of experimental samples

The volatile fatty acids and ammonium concentrations in the silage are presented in Table 4. The presence of volatile fatty acid denotes that the dietary treatments have potential to make energy available to animals (Aluwong et al., 2010). Amongst the acids produced during ensiling, lactic acid should be the primary acid in good silage and is usually responsible for most of the drop in silage pH (Kung and Shaver, 2001). The high concentrations of lactic acid than other acids produced would result in lowest DM losses and energy (Kung and Shaver, 2001). The lactic acid values ranged from 3.24– 4.86% indicating a range of 65.94–67.17% of the total acids produced. This further shows that the silage was a good one as (Kung and Shaver, 2001) reported a range of 65–70% lactic acid of the total silage acids in good silage. The butyric acid concentration range (0.08–0.16%) indicates that the silage did not

Table 1 Physical characteristics of ensiled experimental samples

Diets (%)	Colour	Smell	pH	Texture	Temperature (°C)	Mould Status
A (0 g)	slightly brown	pleasant alcoholic	4.4	Firm	25.5 °C	absent
B (200 g)	slightly brown	pleasant alcoholic	4.3	Firm	25.5 °C	absent
C (300 g)	slightly brown	pleasant alcoholic	4.4	Firm	25 °C	absent
D (400 g)	slightly brown	pleasant alcoholic	4.2	Firm	26 °C	absent

Table 2 Chemical composition of ensiled experimental samples

Parameters	A (0 g)	B (200 g)	C (300 g)	D (400 g)
Dry Matter (%)	47.35 ±0.00^{b}	40.86 ±0.00^{d}	44.70 ±0.00^{c}	54.68 ±0.00^{a}
Crude protein (%)	13.30 ±0.70	13.50 ±14.00	14.59 ±0.84	14.88 ±0.88
Crude fibre (%)	14.67 ±0.82^{c}	17.53 ±0.49^{cb}	22.14 ±1.91^{a}	19.10 ±0.25^{ab}
Ether extract (%)	17.17 ±0.48	19.02 ±2.55	19.08 ±0.49	16.42 ±3.32
Ash (%)	5.29 ±1.39^{b}	5.94 ±0.37^{b}	3.30 ±2.71^{c}	7.27 ±0.43^{a}
NFE (%)	49.57 ±1.03^{a}	40.01 ±11.56^{c}	40.89 ±0.43^{c}	42.32 ±4.02^{b}
NDF (%)	36.64 ±3.68^{b}	22.72 ±21.52^{cd}	23.82 ±21.52^{c}	41.39 ±4.57^{a}
ADF (%)	29.29 ±0.05 ^{ab}	23.77 ±4.45^{b}	31.82 ±1.41^{ab}	37.89 ±5.14^{a}
ME (kcal kg^{-1})	3,396.42	3,644.54	3,552.26	3,656.22

a, b, c, d – means along the same row with different superscripts are significantly (P <0.05) different; NFE – nitrogen free extract, NDF – neutral detergent fibre, ADF – acid detergent fibre, ME – metabolizable energy

Table 3 Mineral compositions (mg/100 g) of experimental samples

Parameters	A (0 g)	B (200 g)	C (300 g)	D (400 g)
Potassium	100.40 ±0.00^{b}	95.90 ±0.00^{c}	108.10 ±0.00^{a}	90.5 ±0.00^{d}
Calcium	61.90 ±0.00^{d}	68.30 ±0.00^{c}	75.00 ±0.00^{a}	72.5 ±0.00^{b}
Magnesium	4.53 ±0.00^{d}	4.86 ±0.00^{b}	4.71 ±0.00^{c}	5.22 ±0.00^{a}
Manganese	0.33 ±0.00^{d}	0.72 ±0.00^{c}	0.83 ±0.00^{a}	0.81 ±0.00^{b}
Copper	0.36 ±0.00^{d}	0.52 ±0.00^{b}	0.40 ±0.00^{c}	0.58 ±0.00^{a}
Iron	1.03 ±0.00^{b}	1.46 ±0.00^{a}	0.70 ±0.00^{c}	0.45 ±0.00^{d}
Zinc	0.47 ±0.00^{b}	0.57 ±0.00^{a}	0.35 ±0.00^{d}	0.41 ±0.00^{c}
Phosphorus	0.08 ±0.00^{a}	0.07 ±0.00^{b}	0.05 ±0.00^{c}	0.03 ±0.00^{d}

a, b, c, d – means on the same row but with different superscripts are statistically different (P <0.05)

Table 4 Volatile fatty acids and ammonium compositions (%) of experimental samples

Volatile fatty acids	A (0 g)	B (200 g)	C (300 g)	D (400 g)
Acetic	1.53^{d} ±0.02	1.85^{b} ±0.02	1.68^{c} ±0.02	2.07^{a} ±0.02
Lactic	3.24^{d} ±0.02	4.27^{b} ±0.02	3.97^{c} ±0.02	4.86^{a} ±0.02
Propionic	0.11^{c} ±0.02	0.21^{b} ±0.02	0.15^{c} ±0.02	0.28^{a} ±0.02
Butyric	0.08^{c} ±0.02	0.14^{b} ±0.02	0.11^{b} ±0.02	0.16^{a} ±0.02
Ammonium	6.87^{d} ±0.02	9.13^{b} ±0.02	8.79^{c} ±0.02	9.38^{a} ±0.02

a, b, c, d – means on the same row but with different superscripts are statistically different (P <0.05)

undergo clostridia fermentation. High butyric acid has sometimes induced ketosis in lactating cows due to poor energy value; intake and production can suffer (Kung and Shaver, 2001). The acetic acid produced would not depress intake when fed to ruminants. Values >4–6% depressed intake (Kung and Shaver, 2001). The ammonium values (6.87–9.38%) show that there was no excessive protein breakdown in the silo and the problem of ammonium toxicity would not occur when fed to ruminants. Most silages typically are low in propionic acid. The low concentration (0.11–0.28%) of propionic acid observed could be due to the dry matter of the silage as Kung and Shaver (2001) reported that very high values is associated with very wet (<25% DM) silage. The normal concentrations of these acids produced indicate that the silage was aerobically stable.

4 Conclusion

Ensiling *Moringa oleifera* leaves, cassava peels and palm kernel cake with *Zingiber officinale* resulted in stable silage with normal concentrations of the volatile fatty acids and ammonium that will not cause deleterious nutritional effect to ruminant animals when consumed. Hence, *Zingiber officinale* could be incorporated up to 400 g in ruminant diets.

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